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ORGANIZATION RESEARCH PROGRAM

What Can We Expect from Our New Economy?

W. H. Gruber

September 1963 35-63

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Work on this project was financed in part by the Center for Space Science at M.I.T. Two very able research assistants, David Greenberg and Robert Morris, contributed significantly to this study. Helpful comments by Len Silk, Senior Editor and economist at Business Week and my colleagues in the School of Industrial Management at M.I.T. - Professors Kuh, Marquis and Zannetos and Otto Poensgen are gratefully acknowledged. The opinions expressed are those of the author and the Space Center and the above-mentioned personnel are not to be held in agreement.

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ABSTRACT

An attempt to evaluate the performance of the postwar economy as compared with the prewar economy of 1909-29 and of 1909-48. Growth of GNP is viewed against the background of increases in labor and capital inputs. Faster growth in GNP despite much lower inputs of labor in the postwar period is found, leading to the conclusion that the postwar economy is different from and more efficient than the economy of the earlier periods. Increases in man-hour productivity and in the stability of the growth process are used to illustrate the nature of the new economy. The changed role of government and the increased inputs of R&D and education are posited to be the factors explaining the improved performance. A critical analysis of a widely quoted article by Robert Solo (HBR, Nov.-Dec., 1962) which came to diametrically opposite conclusions is used to foster a greater awareness of the new economy. The article concludes with the problems and prospects the nation must face in the following decade.

What Can We Expect from Our New Economy?

At one time people relied upon the weather to increase production and witch doctors were in demand to pray for rain and fertility. Today we are amused by such antics and congratulate ourselves on our greater sophistication and knowledge.

Witch doctors have been replaced by economists, but people are still interested in the functioning of the productive process.

The interest and concern of businessmen has been welcomed by economists and political leaders. Witness President Kennedy's now famous appeal for a dialogue on economic issues and his September, 1963, article in Nation's Business. It is well known that the government has since the 1930's played an increasingly active role in ministering to the economic health of the nation. Inasmuch as business must function within the context of relevant governmental action, business interest in the formulation of government policy is easily understood.

In order that businessmen may plan wisely and in order that they may play an active role in the formulation of national economic policies it is necessary that they understand the changes that have occurred and are occurring in the economy so that they may gain perspective for the evaluation of the national economic performance. Past trends often act as oracles for the future and yet how much does the businessman know about the performance of the postwar economy as compared with the pre-depression economy?

Inasmuch as it is our belief that the postwar economy has been greatly shaped by forces of relatively little importance to the prewar economy, the postwar period is not herein viewed as a period of catching up with a long-run trend. Rather the postwar economy is seen as a period in which a whole new set of economic variables has gradually evolved to result in the formation of a new economy relative to previous trends. A new trend emerges that is largely independent of, even though derived from, the prewar structure of the economy.

If there is to be a dialogue, facts are needed. We will demonstrate here that the economy has grown faster in the postwar period with inputs of labor and capital which were relatively small when compared with previous periods. The improved performance must be attributed to increased productivity and the historical record of output per man-hour will be outlined. Then explanations for this rather remarkable performance will be posited and some conclusions about the opportunities that the next decade has to offer will be suggested.

THE ECONOMIC RECORD SINCE 1909

A. Growth in Gross National Product

It is customary to evaluate the progress of an economy by the compound rate of growth in gross national product (GNP) between two periods at the same stage of the business cycle, usually peak to peak. GNP is the sum total of goods and services produced in an economy during whatever period is under consideration. In this context it is useful to mention that for the purposes of this paper GNP will be measured in real terms (i.e., constant-value dollars) in order to screen out inflation. Without this precaution a country such as Brazil would be growing at many times the rate of the United States.

The difference between absolute and relative changes should also be emphasized. A 3 1/2% rate of growth for 1963 requires an increase of almost $17 billion (in 1954 dollars which will be the constant-value dollars used throughout the article)

which would almost equal 16% of GNP in 1909. Paraphrasing slightly, it is true that, in absolute terms, we must run much faster today just to maintain the same rate of growth.

A means of illustrating the significance that a "slight" difference in rates of growth can make was aptly illustrated by Edward Denison.* He noted that at the end of 20 years an economy growing at the rate of 4% a year would be larger by 44% than the same economy growing at a rate of 3% over that same time period. The 1% difference is 33 1/3% greater than the 3% slower alternative. (The difference between 33 1/3% and 44% arises through the compounding process.) If population grows as projected at a rate of 1.9% a year between 1960 and 1980, then the 3% rate of increase in GNP would result in an approximate increase of 1.1% per year in per capita GNP, whereas the 4% rate of increase in GNP would result in an approximate increase of 2.1% per year in per capita GNP. This latter figure is 182% of the 1.1% annual increase in per capita GNP derived from the 3% growth level.

Now that the rules of the game have been established, let us look at the data. Chart I divides 1909-1962, the period covered by the Department of Commerce statistics, into two subperiods with 1948 as the dividing line. From 1909 to 1948 GNP grew at 2.69% a year. In the postwar period, 1948-1962, the annual rate was 3.5%. Because of the faster rate of growth in this latter period, the long run rate of growth from 1909 to 1962 was 2.9% while the growth from 1909 to 1929 (a period free of much of the "government interferences" that we know today) was 2.83% and from 1929 to 1948 it was 2.55%.

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* The Sources of Economic Growth in the United States and the Alternatives Before Us, Supplementary Paper No. 13, Committee for Economic Development, New York, pp. 4 and 5.

RATIO SCALE

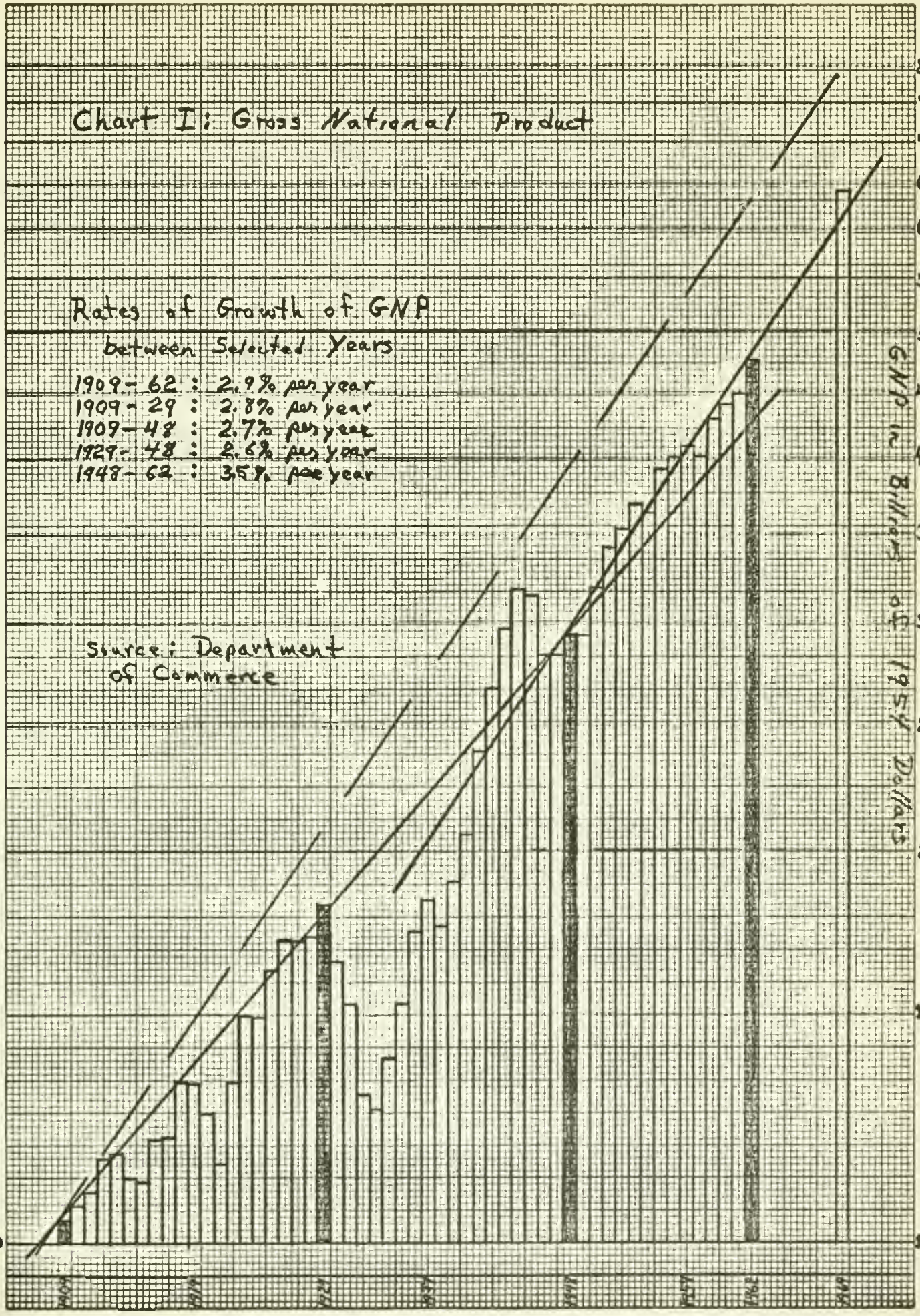
Chart I: Gross National Product
Rates of Growth of GNP
between Selected Years
1909 - 62 : 2.9% per year
1909 - 29 : 2.8% per year
1909 - 48 : 2.7% per year
1929 - 48 : 2.6% per year
1948 - 62 : 3.5% per year
Source: Department of Commerce
Logarithm of Real GNP
2.90
2.80
2.70
2.60
2.50
2.40
2.30
2.20
2.10
2.00
GNP in Billions of 1954 Dollars
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100

To demonstrate the critical difference between a growth rate of 3.5% and one of 2.9% (and .6% does seem very small), we have started a 3.5% growth line from 1909. It will be observed that if the economy had maintained its postwar rate for the period since 1909, GNP in 1962 would have been $643.9 billion or 35.6% above the actual level of real GNP in 1962 of $474.8 billion.

Is It Meaningful to Divide the Record in 1948?

It is difficult to find long periods in the 20th century without wars or severe depressions. A long period is necessary, however, in order to have a meaningful time apan as a basis for comparisons. Short sprints of growth or decay are too frequent to establish a long run projection from them. As the period 1909 to 1948 includes the great depression of the 1930's and World War II, the reader may want to compare the postwar period with the period 1909 to 1939 when the economy grew at an annual rate of 2.83%. We see no reason to go back before 1909 as the data becomes less reliable and the nature of the economy grows less similar to that of the current period.

We chose 1948 as a key year because it was the peak of a business cycle. Unemployment was only 3.78%* of the labor force, which compares favorably with other periods of relative prosperity during our economic history. Additionally, The rate of increase in /productivity, as measured by two sources, did not fall during the period 1929 to 1948, which would indicate that the net effect of the disruption did not unduly slow economic progress below its past rate of change.

---

* Employment and Earnings, January 1963, Table I - 1.

Table I

Rate of Increase in Output per Man-Hour

Private Domestic Economy
(annual average compounded growth)

	1909-1948	1929-1948	1909-1929
Kendrick*	2.26%	2.39%	2.13%
Bureau of Labor Statistics**	1.92	2.24	1.63

Denison*** attributed the faster rate of increase during the postwar period to a catching up with the long run GNP trend line of 2.9%. As we have observed, one cannot agree with Denison if one examines the level of the business cycle or the change in productivity. One might, however, argue that to some extent non-cyclical pent-up demand from World War II was a factor in spurring the economy on to a faster growth rate in the postwar period. That explanation does not, however, seem to hold up well under an examination of trends in actual inputs during that period relative to past periods, as we hope to demonstrate.

If the economy has not changed and if a faster long run rate of growth is not to be expected after we have caught up with our long-run trend, then one would expect that the economy today would not be able to maintain its present rate of growth of 3 1/2% with so little strain on capacity.

The Department of Commerce**** has projected through 1970 an annual rate of GNP growth of between 3.9% and 5.2%. We have indicated on Chart I their median

* Kendrick, John, Productivity Trends in the United States, National Bureau of Economic Research, New York, 1961.

** Bureau of Labor Statistics No. 1249, Trends in Output per Man-Hour in the Private Economy, 1909-1958, pp. 17-18.

*** Op. cit. pp. 18-19.

**** Statement of Luther Hodges, Secretary of Commerce, before the Employment and Manpower Subcommittee on Labor and Public Welfare, May 20, 1963.

estimate of 4.6% through 1969. The National Planning Association,* one of America's leading specialists in long-run economic forecasting, has predicted a rate of growth of 4.5% between 1962 and 1973. The Rockefeller Panel Reports** state that "a growth rate of 5 per cent is possible if we realize fully our impressive opportunities for economic expansion. If the problems of growth are formidable, we have also found the impetus of our economy enormous."

The prospects for continuing growth at a rate faster than that of the prewar period would therefore indicate that we are in an improved economy vis-a-vis our past. In the sections that follow we will adduce in support of our contention statistics that indicate a marked contrast in input trends relative to output between the two periods.

B. Stability of Growth

Few would deny that the best of all possible worlds would be to have fast growth in a stable economy. Compared with our past, the history of the economy in the postwar period has been remarkably stable. Chart II delineates the sharp improvement in the functioning of the economy during this period. Between 1909 and 1929 the economy suffered seven decreases in output, three of which were greater than 4%. In marked contrast to this is the postwar period which witnessed only three decreases from one year to the next. Moreover, none of the decreases attained a magnitude of even 2%.

In Chart III we present the percentage deviations from the two trend lines, 1909-48 and 1948-62. Observe that the economy rarely enjoys a rate of output equaling its hypothetical rate as determined by the trend line. Note also that during the period 1962-63 the economy attained a rate of output equal to its new long-run trend of 3.5% despite an unemployment rate not less than 5.5% during 17 of the 20 months following January 1962 (as of this writing).

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* The New York Times, September 8, 1963.

** Prospect for America, Doubleday and Company, New York, 1961, p. 321.

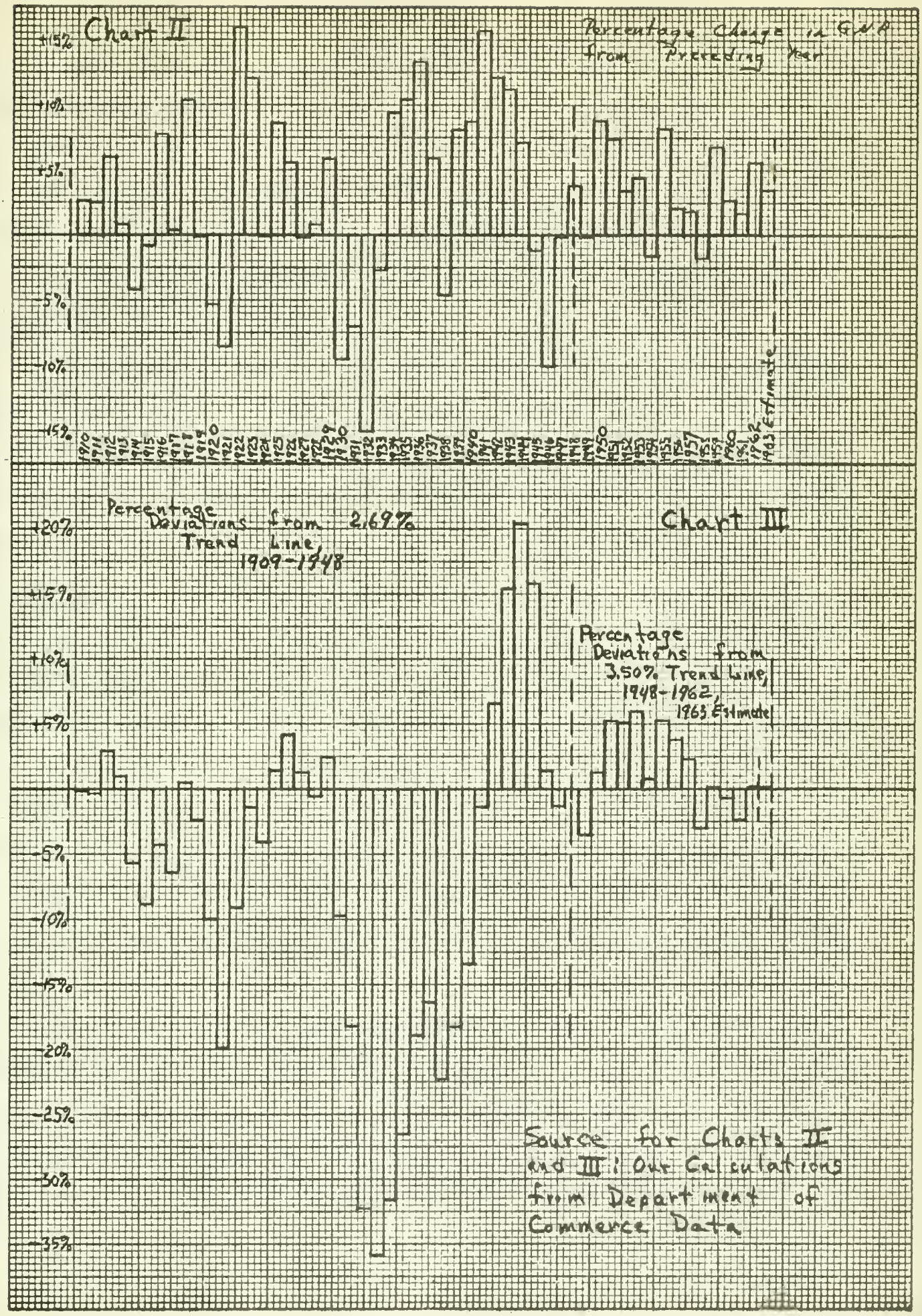
Chart II
Percentage change in GNP from Preceding Year
+15%
+10%
+5%
-5%
-10%
-15%
1910 1911 1912 1913 1914 1915 1916 1917 1918 1919 1920 1921 1922 1923 1924 1925 1926 1927 1928 1929 1930 1931 1932 1933 1934 1935 1936 1937 1938 1939 1940 1941 1942 1943 1944 1945 1946 1947 1948 1949 1950 1951 1952 1953 1954 1955 1956 1957 1958 1960 1961 1962 1963 Estimate
Chart III
Percentage Deviations from 2.69% Trend Line 1909-1948
Percentage Deviations from 3.50% Trend Line, 1948-1962, 1963 Estimate
+20%
+15%
+10%
+5%
-5%
-10%
-15%
-20%
-25%
-30%
-35%
Source for Charts II and III: Our Calculations from Department of Commerce Data

POSTWAR BURDENS ON GROWTH

In this section we will attempt to show that the trends in input patterns of the postwar period are disappointing when compared with those of the prewar period and those projected to 1980. Yet despite the burdens on growth entailed by the record of input trends during the postwar period the economy attained an annual rate of GNP growth of 3.5%.

If the productivity trends of the postwar period can be expected to continue during the period 1962-1980, then, in the light of expected changes in input patterns, an optimistic view of the future is warranted. A later section of the paper will treat the problem of productivity, its determinants, and its expected performance over the span 1962-80.

A. Labor Inputs

An outstanding feature of the postwar period was the relatively small increase in labor inputs. Because of the low birth rates of the depression period, the population of working age (18-64) grew at a rate less than 50% of that experienced in the first three decades of this century.

Charts IV A-D tell the story of trends in labor inputs. Observe in Chart IV C that the population aged 18-21 increased 7.4% in the decade of the 50's but will increase 48.2% in the decade of the 60's. During the 50's there was a decrease of 3% in the population aged 20-24 whereas this same group will increase by 53.3% during the 60's.

As we shall see in a subsequent section, the increase in educational attainment of the labor force is one of the main developments differentiating the postwar economy from earlier periods. The new workers of the 60's will, on the average, be far better educated than those of preceding decades. Thus the faster increase of the labor force in the 60's is more significant from the point of view of

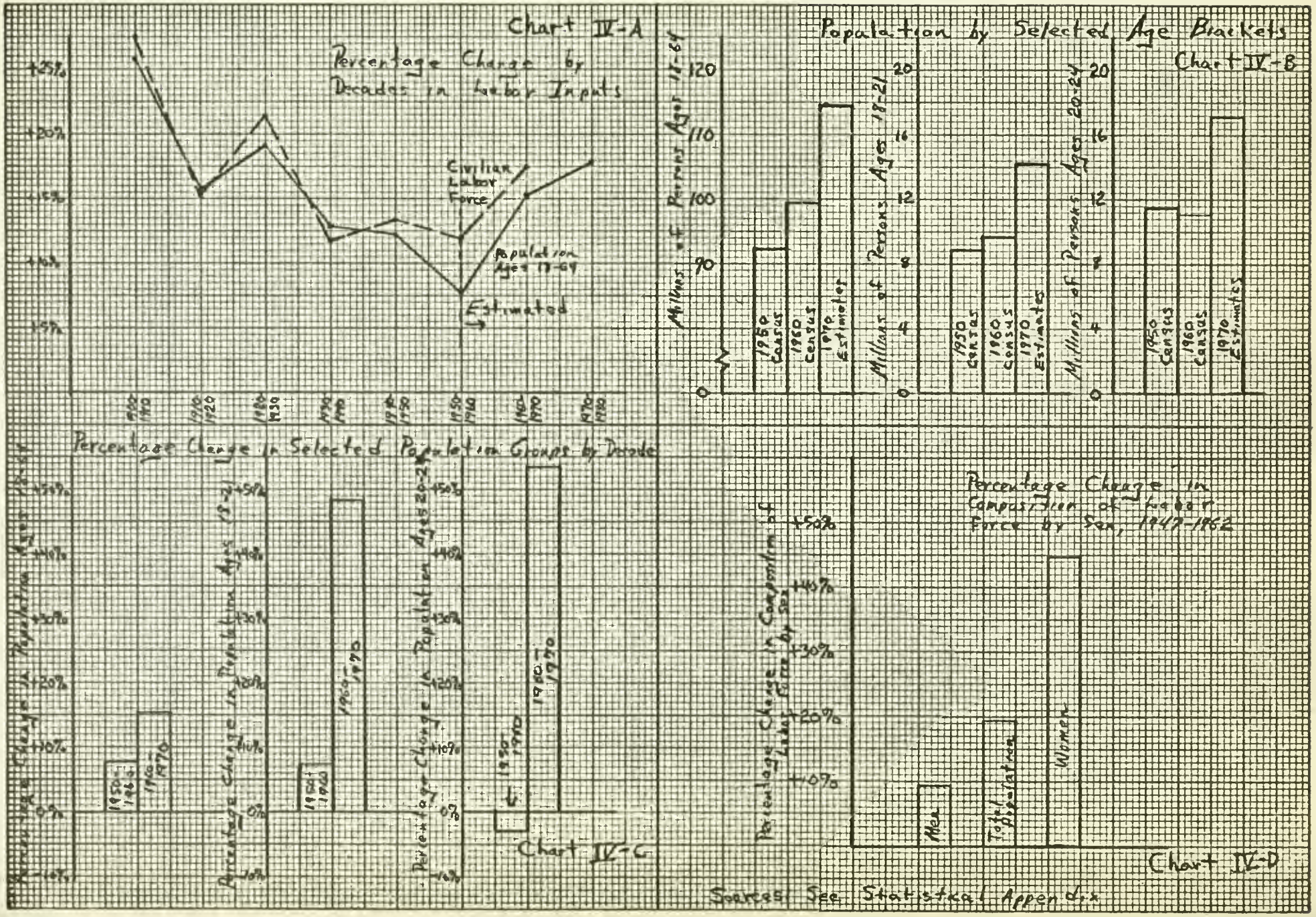
Chart IV-A
Percentage Change by Decades in Labor Inputs
Civilian Labor Force
Population Ages 18-64
Estimated
Population by Selected Age Brackets
Chart IV-B
Millions of Persons Ages 18-64
Millions of Persons Ages 18-21
Millions of Persons Ages 20-24
1950 Census
1960 Census
1970 Estimates
Percentage Change in Selected Population Groups by Decade
Percentage Change in Population Ages 18-64
Percentage Change in Population Ages 18-21
Percentage Change in Population Ages 20-24
Chart IV-C
Percentage Change in Composition of Labor Force by Sex
Percentage Change in Composition of Labor Force by Sex, 1947-1962
Men
Total Population
Women
Chart IV-D
Sources: See Statistical Appendix

increasing labor inputs than the numbers alone would indicate.

The increase in the labor force during the 50's was further affected by the composition of the increase. In 1947 men composed 72% of the total civilian labor force compared with a figure of 68% in 1960. Because of (1) increased military demands on men, (2) the changed nature of housework which freed women of the need to stay home, and (3) the rapid increase in demand for teachers and office help, women made up 64.1%* of the total increase in the civilian labor force from 1947 to 1960 because they were able to increase their participation rate (36.6% in 1962 compared with 31.0% in 1947).**

Thus we see that the impressive rate of growth of the postwar period was accomplished despite the relatively small increase in the number of males in the civilian labor force. But this tells only part of the story, for there was a very dramatic drop in the number of hours worked. In 1929, according to Knowles***, the average annual hours worked per employee was 2,528. This is a decline of 6.4% from the 2,704 hours estimated for 1909. By 1948 the average annual hours worked had declined a further 13.9% (relative to 1929), to reach 2176 hours. By 1958 hours worked had declined another 5.5% (relative to 1948) to bring the total down to 2,057.

Executives may wonder where all the free hours have gone. But that is the price of glory. For the country as a whole, the decline in hours worked represents a substitution of leisure for production. While this transfer does not enter into the measurement of GNP, it represents an increase in human welfare--provided that the increase in leisure is valued more highly than the production lost.

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* U.S. Bureau of Labor Statistics, Employment and Earnings, Vol. 9, No. 11, May 1963, p. 2 Table A-2.

*** Knowles, James W., The Potential Economic Growth in the United States, Study Paper No. 20, Joint Economic Committee, January 30, 1960, pp. 26-27.

** U.S. Department of Labor, Manpower Research Bulletin No. 1, Revised, July 1963, p. 65.

B. Capital Inputs

In turning to a consideration of capital, it should be remarked that we have much better information on labor inputs than on capital inputs. Problems of price level changes, retirement, capital consumption and investment that is expensed -- all of these combine to make our measurement of capital inputs more ambiguous than we should like.

Nevertheless, the available statistics do seem to indicate that there has been a lesser increase in capital inputs during the postwar period than in preceding periods. Also indicated is the fact that the ratio of capital stock to input has been lower in the latter period because of the low levels of investment during the depression and during World War II. Rather than making dubious emendations to the data, we think it will suffice, for the purposes of this analysis, merely to conclude that the faster growth of GNP during the postwar period cannot be explained by larger-than-usual capital inputs.

This can be seen from Table II which shows the percentage GNP and of NNP (net national product) that investment has comprised in these periods. Given the low investment levels of the depression and of World War II, the decline in capital-output ratios should come as no surprise. Table III presents capital-output ratios under three different concepts of capital. It is easily seen that, independently of how one measures the stock of capital, capital-output ratios have decreased from those prevalent in the earlier periods of this century.

This means that business has been using capital more efficiently. For example, in the period 1909-1928 it took, on the average, $3.50 in net capital stock to produce $1.00 in net national product. In the period since World War II, 1946 to 1955 (the last date given by Kuznets), the capital needed to produce $1.00 of net national product was only $2.50.

Table II*

Percentage Shares of Capital Formation in National Product, Based on Volumes in Current Prices

Commerce Concept

Per cent of Gross National Product

Periods	Gross Capital Formation	Net Capital Formation	Percent of Net National Product
			Net Capital Formation
1899-1908	21.4	11.6	12.9
1904-1918	20.5	9.9	11.0
1919-1928	20.6	9.5	10.7
1929-1938	14.5	1.9	2.2
1939-1948	17.5	4.9	5.6
1946-1955	20.2	5.1	6.0

Table III**

Ratio of Capital Stock to Average Annual National Product Per Decade, Based on Columes in 1929 Prices, 1899-1955

Commerce Concept

Intervals for Capital Stock, Geometric Mean of Terminal Years	Periods for National Product, Annual Averages	Ratio of Gross Capital Stock to Gross National Product	Ratio of Gross Capital Stock Net of Retirements to Net National Product	Ratio of Net Capital Stock to Net National Product
Total stock and product				
1899 & 1909	1899-1908	5.3	4.5	3.4
1909 & 1919	1909-1918	5.9	5.0	3.6
1919 & 1929	1919-1928	6.0	5.0	3.5
1929 & 1939	1929-1938	7.3	5.7	3.9
1939 & 1949	1939-1948	5.4	3.8	2.5
1946 & 1955	1946-1955	5.4	3.6	2.5

* Kuznets, Simon, Capital in the American Economy National Bureau of Economic Research, 1961, p. 96

** Ibid., p. 80

C. Taxes as a Burden on Growth

It is probable that, during the next decade, taxes will not weight as heavily on the economy as they now do. To make tax reduction possible cooperation between business leaders and government is needed. Congressmen report during recent debates that there has been little popular support for tax reduction. This may be due to a lack of understanding by the general public of the economic issues involved. The Wall Street Journal* recently reports that "In addition to their respective duties as Chairmen of Ford Motor Co. and General Motors Corp., Messrs. Ford and Donner are members of the 'Business Committee for Tax Reduction in 1963.' This fast-growing group of corporate executives is beginning to generate some detectable tax-cutting pressure on a Congress that otherwise is feeling little heat from the folks back home."

The slower record of growth in the latter part of the 50's can, to a considerable degree, be explained by restrictive government policies. High tax rates create a government surplus when the economy moves rapidly ahead. This in turn chokes off growth. Arthur Burns explained the "unsatisfactory character of the business-cycle expansion from 1958 to 1960" in these terms. "Between the first quarter of 1959 and third quarter of 1959 the Federal cash deficit, allowing for seasonal factors, fell from an annual rate of $17 billion to $2 billion. By the second quarter of 1960, we were already operating with a surplus at an annual rate of $7 billion. Thus, in a period of little more than a year, we had a turnabout in Federal Finances of about $24 billion."**

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* "Business Lobby Group Seeks to Offset Public Apathy Over Tax Cut," The Wall Street Journal, July 19, 1963.

** Arthur Burns, "Examining the New 'Stagnation' Theory," The Morgan Guarantee Survey, New York, May, 1961, pp. 4,5.

Burns concluded his section on the slow growth from 1958 by attributing much of it to "government policies of restraint... I haveno doubt that these policies were sound and even essential. But, as happened in the event, they were pushed with excessive vigor and they were not checked in time."

The expectations generated by the Kennedy proposals for tax reform and reduction have acted as a spur to the present recovery. If the pending tax legislation is passed, there is reason to believe that the present recovery will be one of the longest in American economic history. In this context it is interesting to note that the present recovery is (as of the date of this writing) already in its thirtieth month. The average length of postwar recoveries, according to the National Bureau of Economic Research as reported in The Wall Street Journal,* is 32 months -- "excepting the abnormal 1949-53 expansion" which was 45 months in duration. It is highly probable that, if the President's tax proposals are passed by Congress, the present recovery will continue to set a longevity record for the twentieth century.

An Explanation for the Postwar Period

The 3.5% rate of growth of the postwar period has been achieved despite the various burdens enumerated above. How has this been possible? By answering this question, we can determine national policies for implementing faster growth. We will also be better able to predict economic performance.

It is clear that government action has played an important role in the performance of the postwar economy. The present economy recovery is in large measure a result of the faster depreciation allowances, the investment credit, increased government spending, and specific help for the unemployed and for depressed areas. Thus,

* The Wall Street Journal, September 8, 1963, "The Lively Upturn."

enlightened fiscal and monetary policies of the Federal Government provide, with the exception of the latter part of the 1950's, a partial explanation for the relatively high level of performance and stability of the postwar economy. Such programs as social security and unemployment insurance, begun in the 30's, are also helping the economy today. Since the goal of growth is served by increasing demand, government spending that has grown out of the Korean War and other defense needs does provide a partial explanation.

To complete the picture, however, an examination of man-hour productivity is called for.

First we will look at great improvements made in the field of productivity. To explain the relatively rapid rate of increase in output per man-hour experienced in the postwar period we will then turn to an examination of education expenditure and of R&D (research and development) expenditures.

Man-hour Productivity

To grow faster while experiencing a decline in labor inputs, the rate of output per man-hour must increase at an even greater absolute rate. We have used two sources of data in our research into this phenomenon.

John Kendrick used man-hours worked in his calculations and the Bureau of Labor Statistics used man-hours paid for, thereby including sick time, vacations, etc. -- time paid for but not actually worked. These two series are summarized in Table IV. Then productivity is compared with growth in GNP in Chart VA by looking at the growth in GNP in combination with the increase in employment, using 1948 as a base of 100. GNP increased by 62.0% whereas total civilian employment increased by 11.5% over the period 1948-62. As the reader will remember, hours per worker have been decreasing over this same period -- by 5.5% through 1958.

Chart VB is then used to trace the Bureau of Labor Statistics data back to 1909 thereby demonstrating the faster rate of productivity growth during the postwar period.

RATIO SCALE

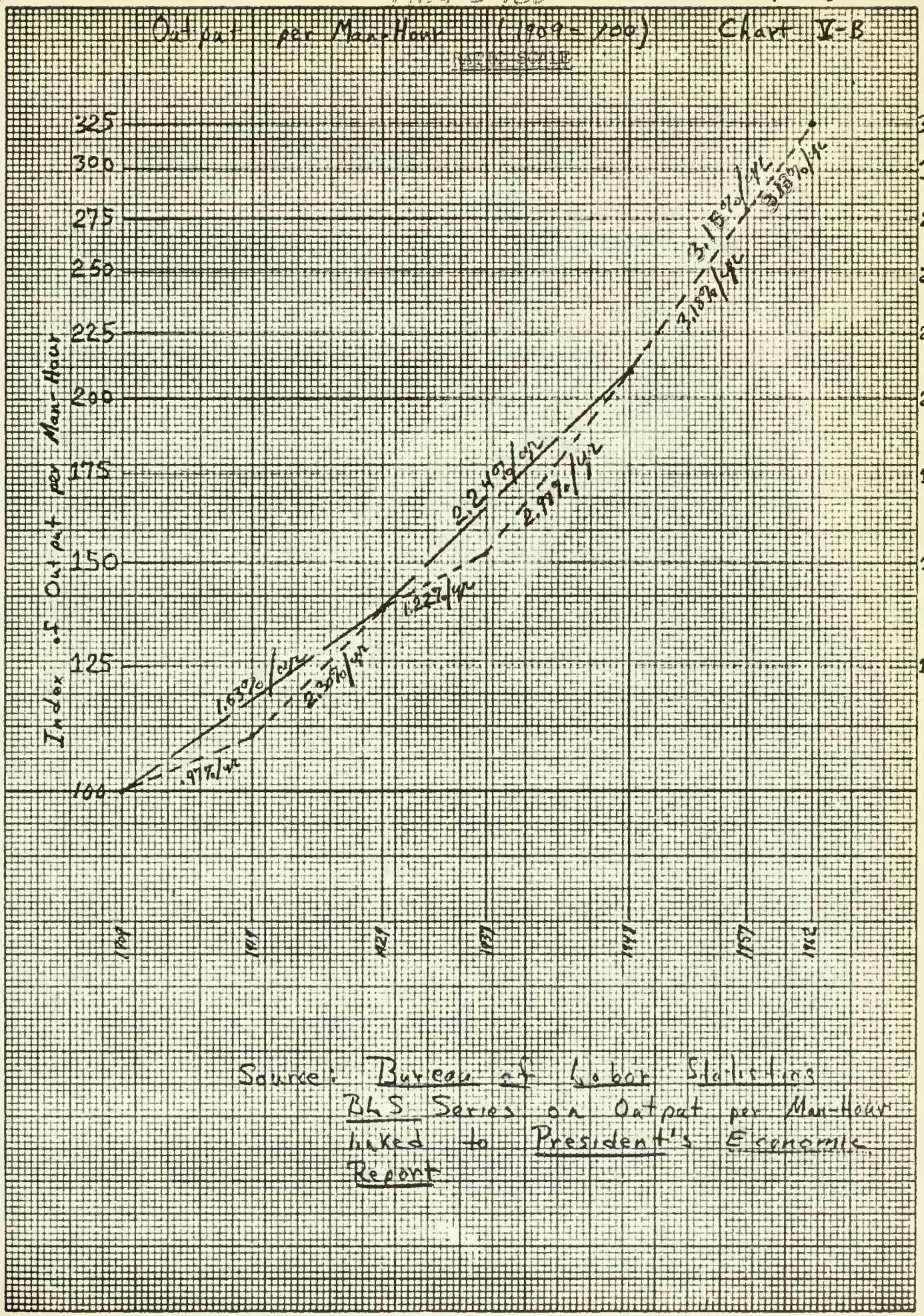
INDEX OF GNP AND EMPLOYMENT Department of Commerce
1948 = 100

Chart V-A

Source: Manpower Report of the President

RATIO SCALE
1909 = 100

b 136



Source: Bureau of Labor Statistics
BLS Series on Output per Man-Hour
linked to President's Economic
Report

Table IV: Changes in Output per Man-hour

Average Annual Percentage Increase for
Selected Subperiods, 1909 - 1963

Private Domestic Economy

	Kendrick*	Bureau of Labor Statistics**
1890 - 1909	1.93	N.A.
1909 - 1929	2.13	1.63
1929 - 1948	2.39	2.24
1948 - 1957	3.41	3.18
1948 - 1962	N.A.	3.16
1909 - 1948	2.26	1.92
1909 - 1957	2.47	2.16
1909 - 1962	N.A.	2.25
1957 - 1962	N.A.	3.13

The Increase in Education and R&D

The ability of economists to make statistical correlations when a large number of interrelated variables affects the outcome is not yet up to the job of making a quantitative correlation between expenditures for education and for R&D and growth in GNP or man-hour productivity.

Before presenting the data, we thought that it may prove instructive to follow through our chain of reasoning so that the reader can check his own impressions against ours:

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* Op. cit., p. 333.

** Bureau of Labor Statistics, Trends in Output per Man-hour in the Private Economy, Bulletin No. 1249, Washington, D.C., 1961, for years 1909 - 1946, President's Economic Report, Jan. 1963 for years 1947-1962.

1. The performance of the economy as measured by the rate of increase of real GNP has been impressive in the postwar period relative to any significant period or subperiods of the prewar era.

2. Yet the postwar period has not seen an increase in labor and capital inputs that matches the rates of the prewar period.

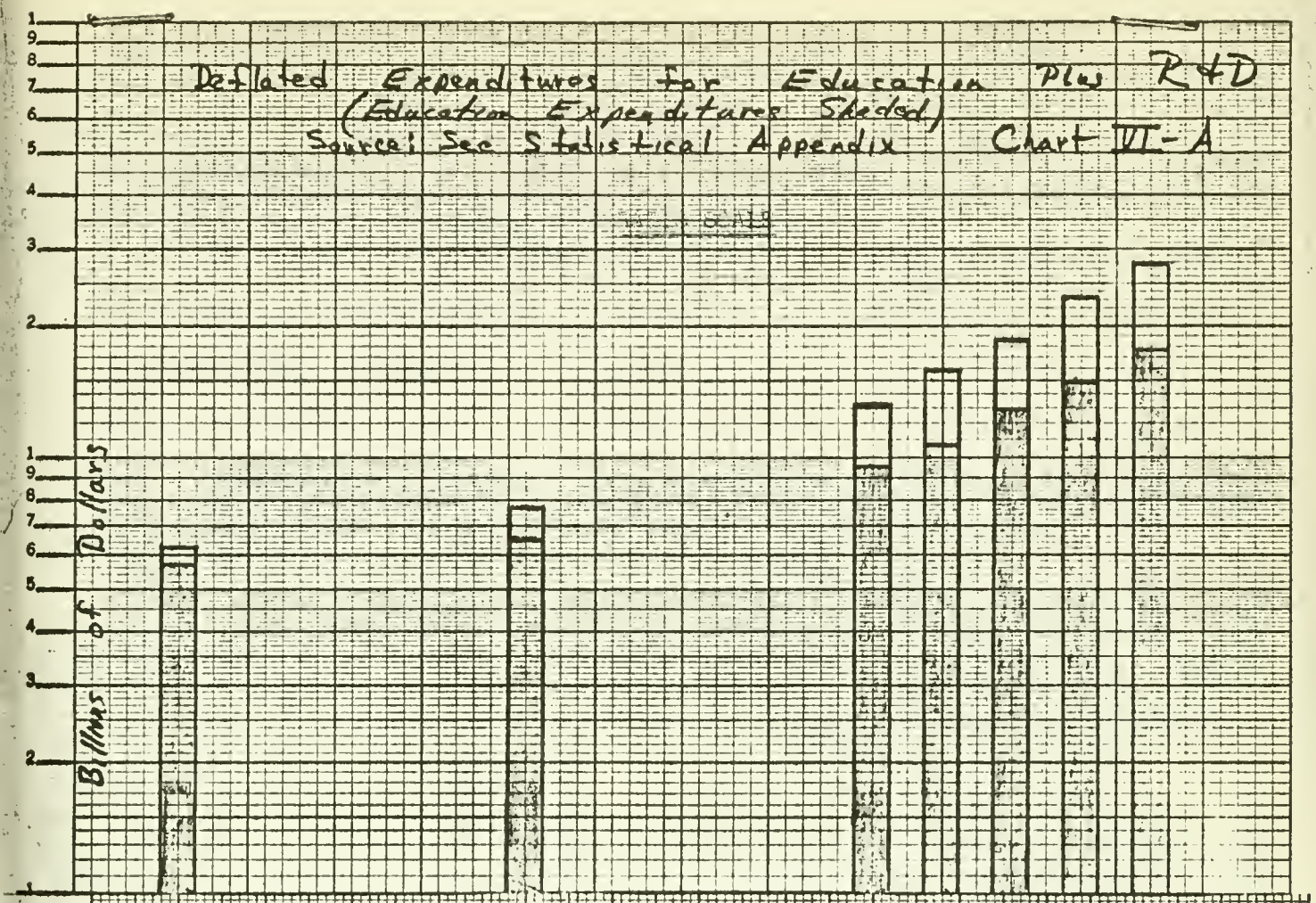
3. Thus one must look to the concept of productivity (output per unit of input -- where the input is usually measured as man-hours of labor) to explain the relatively greater rate of GNP growth of the postwar period.

4. In examining what determines the level of productivity it is only natural to look at such things as education of the labor force, R&D (research anddevelopment), improved working conditions in the context of which the labor force functions, morale of the labor force, and so on.

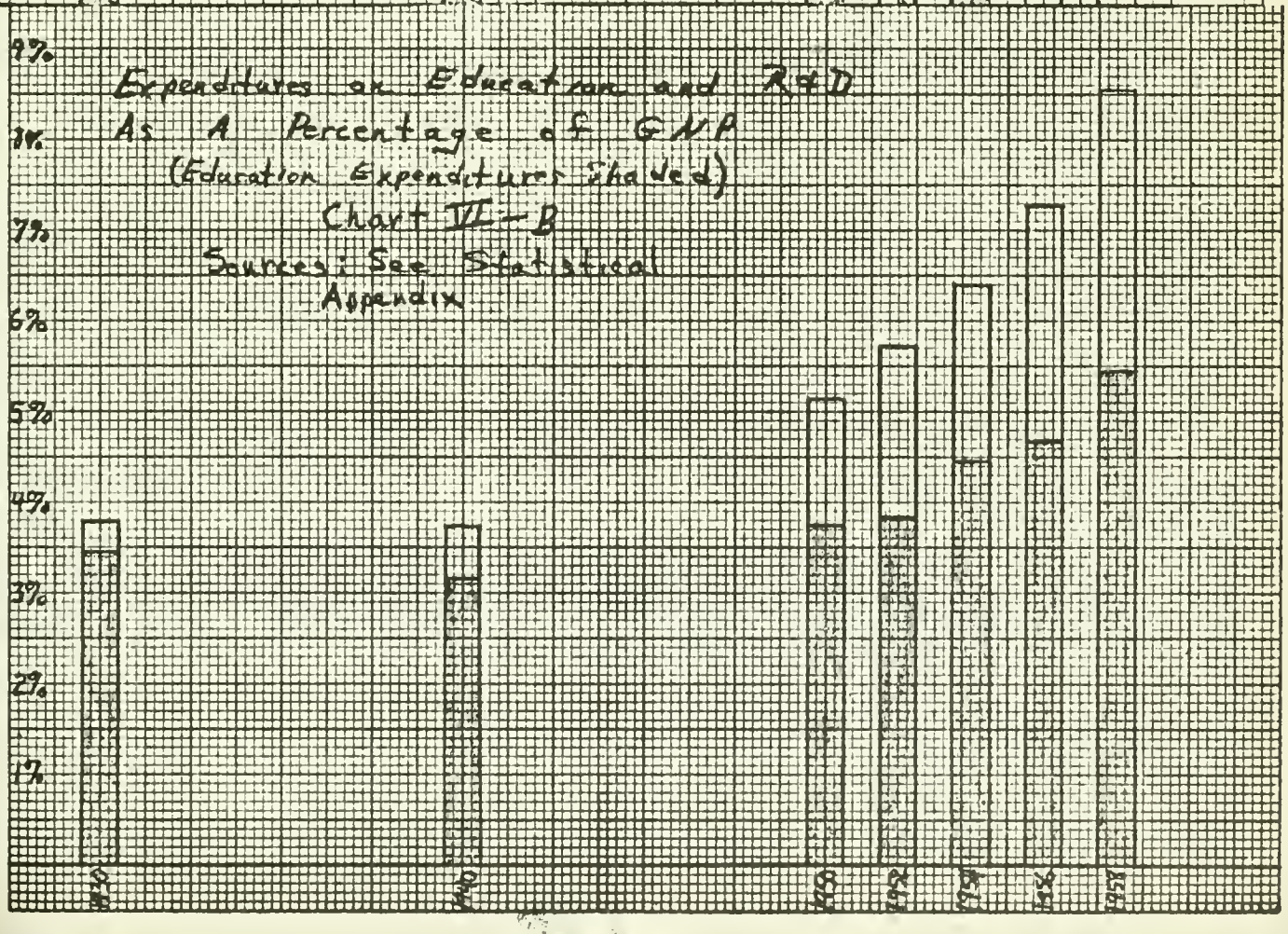
5. Viewing the spectacular increases in the educationsl attainment of the labor force and in the expenditures on R&D, we conclude that a great deal of the increase in productivity can be explained by reference to these same two factors.

In Chart VIA we have added education expenditures to R&D expenditures to provide a crude index of inputs into the process of increasing knowledge. That the rate of growth in this vital portion of the economy has been greater than that of the economy as a whole can be seen by an examination of Chart VIB which shows the rising percentage of GNP that these expenditures represent.

In the presentation of Chart VIA the sum of the expenditures for education and for R&D has been deflated by the GNP implicit price deflator in order to provide a series more consonant with the real GNP series that has been used in earlier parts of this paper. However, inasmuch aa both of these sectors of the economy have grown faster than the average rate of growth for all other sectors, it is highly likely that they have experienced inflationary pressures to a greater degree than



Deflated Expenditures for Education Plus R&D
(Education Expenditures Shaded)
Source: See Statistical Appendix
Chart VI-A



Expenditures on Education and R&D
As A Percentage of GNP
(Education Expenditures Shaded)
Chart VI-B
Sources: See Statistical
Appendix

the average of the other sectors.* Our figures thereby overstate the real input into R&D and education to some degree.

To avoid a dependence on expenditure data, it is useful to look at the statistics of personnel involved in R&D and education. For this data see Tables V and VI and chart VII. When examining the personnel increases in education and R&D as presented in Table V, it may be helpful to keep in mind the fact that production workers in manufacturing declined from 12.9 million in 1947 to 12.4 million in 1962 (see Chart IXC).

Table VI, Enrollment in Institutions of Higher Learning as a Percentage of Population aged 18-21, shows the increase in number of persons attaining at least some college education. Chart VII profiles the changing structure of educational attainment of the American populace.

Not all of this increased education can be considered directly applicable to the sort of knowledge that fosters economic growth. There is no question about the fact that some education can be considered to be consumption similar in many ways to any other consumer good. And one cannot presume that all of the increase in R&D expenditure was made in order to foster economic growth. Let us face facts. Much of what we now do as a nation and of what we have done in the past comes as a result of foreign military pressures. The federal programs now contributing to the well-being of the country (e.g., the National Defense Education Act, the establishment of the National Science Foundation) were not started because enlightened men gathered together for the purpose of allocating funds in the public interest before foreign pressures became manifest.

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* See, for instance, "A Proposed Cost-of-Research Index" Ellis A. Johnson and Helen S. Milton, Johns Hopkins University, Bethesda, Maryland, February, 1961.

Table V

The Input of Personnel in R & D and Education (in 1,000's)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
						R & D Personnel	
	Total engineers	Degrees awarded in engineering (bachelor level)	Total scientists excluding social scientists but including psychologists	Technicians	Total instructional staff in education	Total	acientists & engineers
1900	37.5	N.A.	N.A.	N.A.	470	N.A.	N.A.
1910	77.2	N.A.	N.A.	N.A.	584	N.A.	N.A.
1920	134.1	N.A.	N.A.	N.A.	760	N.A.	N.A.
1930	217.4	7.7	58	N.A.	982	N.A.	N.A.
1931	-	-	-	-	-	73.1	39.5
1940	297.5	15.1	115	300	1007	124.4	69.1
1950	543.0	52.7	200	550	1080		
1951	-	-	-	-	-	363.8	148.5
1960	840	37.8	365	875	1643	1092.7	397.4
1970 (est.)	1400	54.0	625	1600	2047*	N.A.	N.A.

SOURCE: See Statistical Appendix

*Estimate is for 1969

Table VI

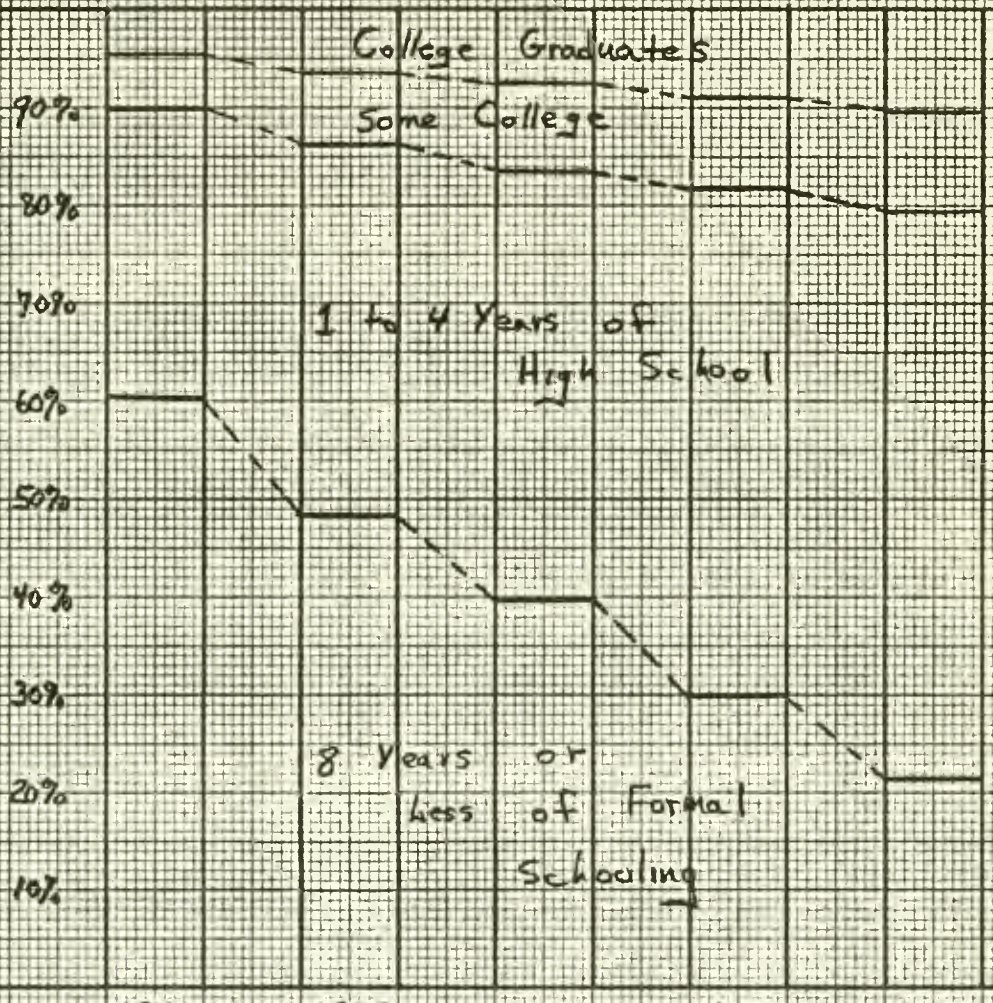
Enrollment in Institutions of Higher Learning as a Percentage of Population Aged 18-21

1900	3.97%
1910	4.86%
1920	8.08%
1930	12.23%
1940	15.40%
1950	25.67%
1960	39.02%

SOURCE: See Statistical Appendix; note: This does not represent the percentage of the population, ages 18-21, in Institutions of Higher Education because enrollment includes students older and younger than 18-21.

Chart VII.

Distribution of Educational Attainment Among Persons 25 Years of Age or Over



Source: U. S. Census of Population — 1960 Summary of General Social and Economic Characteristics; Health, Education, and Welfare TRENDS, 1962

An Analysis of a Conflicting Conclusion

Readers of Robert A. Solo's "Gearing Military R&D to Economic Growth" (Harvard Business Review, November-December 1962) have probably begun to wonder if we are talking about the same country.

Since it is our opinion that businessmen must understand the differences between the pre- and postwar economies if they are to plan their own activities intelligently and if they are to play an enlightened role in helping to shape public policy, we will utilize Solo's findings in order to provide further insight and perspective into our new economy. Given the vast increase in the amount of writing about the economy and R&D, our analysis of Solo's work may also help the reader to become more critical of the volumes of literature that are thrust upon him.

Solo concluded that he could find no correlation between the rise in expenditures for R&D and (1) output per man-hour, (2) growth in GNP, and (3) inventive activity. A study of each of these conclusions will follow.

(1) Output per man-hour

Solo found that despite the rapid increase in expenditure for R&D "the rate at which output per man-hour has increased appears to waver about the same old norm. Indeed, after 1953, while expenditures for R&D skyrocket the rate of increase in output per man-hour slumps."*

Now we discover that GNP has been rising faster than in the past while man-hours of input has been growing more slowly. Is it possible that the rate of growth of output per man-hour did not increase? The obvious answer is given by the sources that Solo used in his own article. Kendrick,** in Table A-XXI, which is the same

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* Solo, op. cit., p. 50

** Kendrick, op. cit., p. 333

table Solo used, has productivity per man-hour growing at a rate of 2.3% per year from 1890 to 1957. From 1948 to 1957 (the last date for the Kendrick data), productivity per man-hour grew at a rate of 3.4% per year. Solo's conclusion that we vary around the "same old norm" is a peculiar way to describe a rate of growth almost 50% greater than the long-run trend and 60% greater than the rate of increase from 1909 to 1929 of 2.13% per year!

Anyone examining Solo's Exhibit IA* could not have determined this difference because his exhibit was drawn incorrectly. For example, the change from 1954 to 1955 was given by Kendrick** to be one from an index of 195.4 in 1954 to 204.8 in 1955 (with 1929 as a base of 100). This is an increase of 4.7% whereas Solo's data lead to a figure of 3%.

The other source given by Solo, the National Planning Association's Economic Projections, enables us to examine still a third source on productivity growth. The findings here agree in direction with those of Kendrick and of the Bureau of Labor Statistics. From 1899 to 1929, in the Total Business Sector, the National Planning Association found an annual increase of 1.6% in output per man-hour; from 1929 to 1948, an annual increase of 1.5%; and from 1948 to 1960 an annual increase of 2.79%.*** It will be recalled that the National Planning Association expects an increase in GNP of over 4.5% per year during the next decade. This is indeed the wrong source to quote to demonstrate that there has been little change in the rate of productivity increase since the advent of increased expenditures for R&D.

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* Solo, op. cit., p. 51

** Kendrick, op. cit., p. 333

*** National Planning Association, National Economic Projections, 1962 Edition, Table 1-17, Washington, D.C.

It should be added that, in the short run, productivity increase and growth in the economy are highly correlated. When economic activity slows down, firms operate with more personnel than they need. A trend toward fixities in the production function has grown as the proportion of indirect workers (most of whom are employees who enter overhead costs) has increased relative to direct workers, who are more easily laid off.

Thus, the President's Economic Report of January 1, 1963, shows output per man-hour increasing at a rate of 4.10% in 1962 and at a rate of 3.41% in 1961, indicating that the slower growth in the late 50's derived from cyclical factors rather than from an inability to accelerate productivity.

(2) Growth in GNP

Solo continues* in his correlations as follows:

> In any case, no positive correlation whatsoever is evidenced between the national rate of economic growth and the national level of R&D expenditures. Much the same conclusion must be reached if we look at other economic indicators -- for instance, the rate of increase in GNP (see Exhibit I-B).
>
> What is the significance of this finding? It does not mean that individual companies have not benefited from R&D, or that great industries have not been created because of it. Clearly they have. Nor does it mean that there have not been benefits to national economic growth from federally sponsored R&D. Most certainly there have been. But it may mean that some other, unspecified barriers to growth have been rising, and have balanced out the mounting benefits of R&D. However, it will be shown later that R&D, as it is currently constituted, can itself be a drag upon, as well as a stimulus to, growth, and hence, that the detriments to growth implicit in R&D itself may not have been sufficiently offset by its benefits.

It is at this point that we should compare Solo's GNP series with our GNP series (seen in Chart I). To trace Solo's work, it is useful to have some understanding of economics. We realized Solo was factually incorrect with respect to output

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* Solo, op. cit., p. 50.

per man-hour when we did not see a rise in his index correlating with the economic expansion of the 1954-55 period. His GNP figures were intriguing because they purported to show a long-run (1919-59) rate of growth of 3.7% which we knew to be factually incorrect.

On examination it appears that what Solo calls GNP is really the Federal Reserve Index of Industrial Production. He then notes that the long-run trends of this index (1919 to 1959) was 3.7% per year which is, indeed, the correct rate of growth for that index during that time period.

Solo asks his readers to see his Exhibit I - B, "Gross National Product ," in order to determine that there is no correlation between economic growth and R&D expenditures. It is apparent that (see Solo's Exhibit I - B above) Industrial Production has grown at substantially more than the 3.7% rate over the period 1948 - 1957. If Solo had read the text of the source from which he had taken his Exhibit I - B, he would have noted the following:

> A report of the Committee for Economic Growth has shown that the annual rate of growth in GNP was 2.9 percent from 1909 to 1957 and 3.6 percent from 1947 to the first half of 1959... Similarly, industrial production has risen more rapidly in recent years than over the total period 1919-1957. It has been stated in the Rockefeller Brothers Fund Report, The Challenge to America: Its Economic and Social Aspects, that output has doubled approximately every 24 years over the last 75 years, but if postwar rates continue, they will double every 18 years.*

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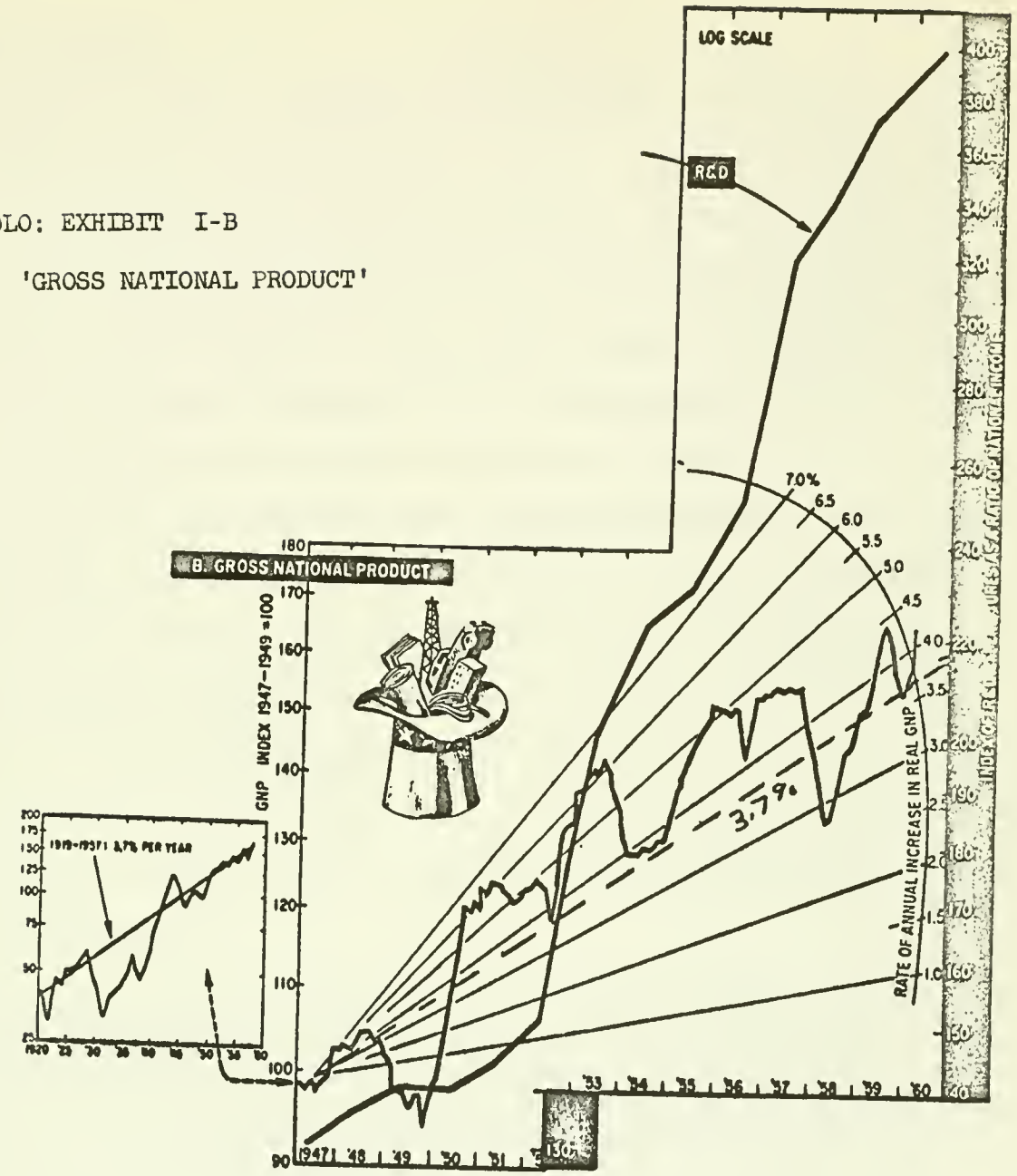
* Robert Theobald, Profit Potential in its Developing Countries, AMA Research Study 53, 1962, p. 30. One cannot resist adding that this quote came from the page opposite the one Solo used. The confusion between GNP and Industrial Production apparently arose when the titles of Graphs IV and V of this AMA study were transposed.

SOLO: EXHIBIT I-B

'GROSS NATIONAL PRODUCT'



SOURCE: Solo, op. cit. p. 51

The 3.7% trend line has been inserted as an aid to the reader. Solo's paper did not include it and thus it was difficult to observe that most of the period was substantially above the 3.7% line, and, in fact, had a rate of increase of 4.1% from 1948 through June, 1963.

3. Inventive Activity

Solo utilizes an index of patents per capita to prove that there is no correlation between R&D and inventive activity. If Solo believes that number of patents issued is a good index of inventive activity, then he will probably want to devote some of his attention to the Germans who have been doing very poorly as compared with the "poor" performance of the United States. Our Chart VIII compares the German performance with that of the United States. When this data is put on a per-capita basis the contrast is every bit as marked.

If Solo had done any research on the utilization of number of patents issued (per capita or otherwise) as a measure of inventive activity, he would probably have come across the National Bureau of Economic Research Study, The Rate and Direction of Inventive Activity.* He would have discovered there that the unanimous opinion of the economic experts at that conference was that number of patents issued is not a good indicator of the level of inventive activity. A good summary of current thinking on this problem is provided by a long-time scholar in this field, Jacob Schmookler.**

> In the meantime, however, we should realize that the biases are probably so strong in the post-1940 period that use of the data even as an index of intermediate period fluctuations in inventive activity in the last two decades is risky. The protracted war depleted the personnel of the Patent Office, the patent bar, and related private services. The proportion of direct, usually unpatented, government invention rose considerably. Even more important, large firms, and perhaps others to a lesser extent, curtailed their use of the patent system for a number of more or less related reasons. Chief among these were (1) a vigorous antitrust policy initiated in the late 1930's under which tens of thousands of patents held by large firms were thrown open to compulsory licensing, (2) the development of judicial attitudes casting doubt on the very patentability of ideas produced in corporate research and development programs, (3) the great growth of government-financed corporate R and D, accompanied

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* Princeton University Press, Princeton, N.J., 1962.

** Ibid., pp. 79, 80.

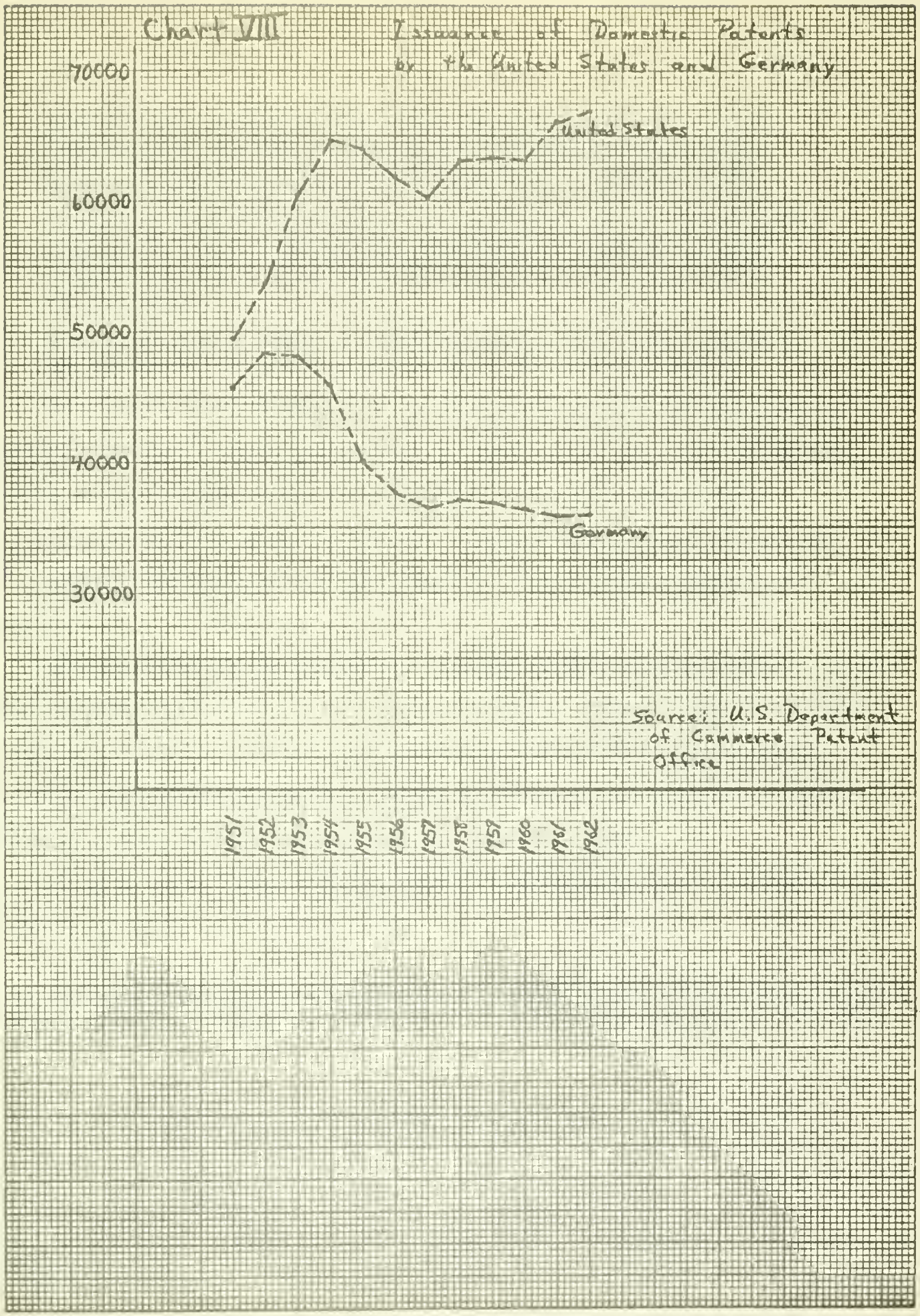
Chart VIII
Issuance of Domestic Patents
by the United States and Germany
70000
60000
50000
40000
30000
United States
Germany
Source: U.S. Department of Commerce Patent Office
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
1961
1962

generally by a government lien on the resulting product which usually diminished the incentive to patent, (4) the prolonged delays at the Patent Office in processing applications, and (5) a growing belief among corporate managers that a head start usually provides all the protection the innovator either needs or can hope for, so that patents seemed less valuable than before. Presumaly in consequence of those developments, while corporate R and D expenditures rose several-fold, patents taken out by firms increased by only one-fifth from 1940 to the mid-1950's.

Thus, after 1940 a number of factors diminish if they do not destroy the utility of the data as a reflection of the inventive effort.

There exists today no measure of inventive activity that is unambiguous or general acceptable. Rather than attempt to create one at this time, we believe it will suffice for the reader to consider two concurrent developments: (1) the improvement in managerial techniques and the rapid increase in the use of computers, quantitative decision making, etc., (2) the rapid outdating of engineers.

When considered in the context of scientific progress both developments provide some insights into the process of inventive activity. In this regard it is interesting to note that M.I.T. has recently been awarded $5 million grant from the Alfred P. Sloan Foundation for the purpose of establishing a Center of Advanced Engineering study in order to deal with the outdating crisis.

Gordon S. Brown,* Dean of M.I.T. School of Engineering, gives a summary of this problem:

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* Gordon S. Brown, "Closing the Engineering Gap," The Technology Review, June 1963, pp. 27-28.

The Dimensions of the Problem

Between 1940 and 1962 our colleges graduated about 600,000 engineers with bachelor's degree, 93,000 with the master's or engineer's degree, and 10,000 with the doctor's degree. Nearly one-half of all of the bachelor's degrees were granted before 1953, or prior to the time when engineering curricula began to take on a stronger scientific base in response to the well-known Grinter Report. About one-quarter of the bachelor's degrees were awarded between 1945 and 1950, a period when there was far less emphasis on graduate study than there is today. Hence, it is reasonable to assume that many thousands of engineers who today are in their late 30's or early 40's were graduated from an essentially pre-World War II curriculum. Many of them had little or no formal graduate study.

To illustrate what this means, I need only say that during the 1945-1950 period few undergraduate engineering curricula included strong courses in the fundamentals of:

1) Modern atomic and nuclear physics, and nuclear engineering;

2) Feed-back control, automation, and inertial guidance;

3) Information theory and advanced theories of communications;

4) Modern computer technology and its penetration into engineering analysis and design;

5) Solid-state physics and molecular engineering, and their impact on the era of solid-state electronics, the exploitation of superconductivity and other properties of modern materials;

6) Plasma physics, its role in the development of techniques for space propulsion, and its potential for new forms for energy conversion;

7) Computer-aided design and numerical control of machine tools as ways to increase the production capabilities of industry;

8) Modern treatments of the interactions of electromagnetic theory with fluid dynamics, with statistical and wave mechanics;

9) Probability theory and its role in engineering decision making;

10) Relativity theory, modern mathematics, etc., and finally

11) Extra-terrestrial sciences.

A.C. Montieth, a Vice-president of Westinghouse Electric Corporation and a former President of AIEE has said that today's graduate engineer has "half life of about ten years," i.e., half ow what he will need to know in '73 is not available to him today.

Thus Solo was factually incorrect or had made improper correlations in each of his three main areas of relationship between R&D and the rate of economic growth. His conclusions about the "barriers of growth" deriving from R&D were grossly unfounded. He reduces the argument of Leonard Silk,* an able scholar and specialist in the field of R&D, to the following syllogism:

> Silk goes on to argue that the advances in information and technology resulting from the U.S. space programs will stimulate progress significantly, "in electronics metals, fuels, the life sciences, ceramics, machinery, plastics, cyrogenics, and, most important ... basic research in all the sciences." His viewpoint -- and many people share it - could be restated as a syllogism:
>
> 1. Economic growth is generated through technological advance.
> 2. Technological advance derives from new scientific and technical knowledge.
> 3. New scientific and technical knowledge is the consequence of R&D.
> 4. Hence, an increase in R&D must accelerate the rate of economic growth....
>
> Then Solo concluded:
>
> This might seem, indeed a self-evident truth. But alas - like many another such truth - it fares badly when measured against the evidence.

The most serious barrier to growth is not the failure of R&D to increase the capacity to supply, as Solo indicated. Instead, it is the success of the new economy in creating an efficient system which has provided a capacity to supply in excess of levels of existing demand. Excess capacity leads to a reduction in investment, thereby reducing the embodiment of new technology into the productive process. It reduces the labor force, as fewer people look for work. It fosters resistance to technological change by workers. It encourages labor unions to seek longer vacations and shorter hours in order to spread work. All of this results in part from the success of R&D and education in speeding productivity increases.

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* An interesting and informative book which explores the impact of R&D into the economy is Silk's The Research Revolution, McGraw-Hill Book Company, New York, 1960.

It is true that the R&D process can be made more efficient. The need for improvement is natural in any phenomenon which has grown as rapidly as R&D during the last decade. By definition, R&D involves pushing into the unknown. Thus it is an uncertain and innately inefficient process. Although we agree with Solo that the R&D process can be improved, we feel it important to emphasize that the health of the economy depends to a far greater degree upon coping with the contribution that R&D has made in increasing the capacity of the economy to supply.

The American businessman of the 60's will have tremendous opportunities if wise policies are pursued by the Federal government. An understanding of our economic performance is essential if businessmen are to make a positive contribution to the formulation of these policies. It is with this in mind that we made reference to Solo's article -- to provide a means of probing what has actually happened in the economy.

A Warning about Economic Correlations

Let us stop for a moment and ask ourselves what it would have signified if Solo had been correct and the American economy had not performed better in the postwar period despite the massive input into R&D. Would Solo then have been justified in his conclusion that R&D was not helping the economy?

Some reflection on this should lead to a negative answer. Even if Solo's facts had been correct, it might not follow that his conclusions were sound. The rising expenditure on research is in part explained by the fact that the inventive process has become more costly as our economy has become more technologically complex. It may be helpful to reflect on modern inventions and compare them with similarly functional products of the prewar period. For example, jet engines versus piston engines, computers versus adding machines, color television versus radio, numerical machines versus hand milling machines...

The list is endless and the conclusion is clear. We live in a world in which many of the easy inventions have already been invented. In order to make progress over the past, it is necessary to run harder even to stay in the same place. The Queen from Alice in Wonderland would feel right at home.

An explanation of the word "easy" is in order. To invent the electric light was not "easy" when one puts the matter into the context of the state of scientific knowledge of that day. If we were to measure cost by the percentage of the available scientific talent and resources consumed in the process, we might discover that the invention of the electric light was more costly than the invention of atomic power -- particularly if this recent accomplishment were costed in relative terms. But we do not measure in this way but rather consider only costs that enter into gross national product. Furthermore, the trend is away from inventors working at their own cost and time (not entered into R&D costs) and toward corporate research which provides and accounts for these expenditures. Income tax laws and definitional procedures have helped to account for the rise in R&D expenditures over time as well. Thus the combination of the way costs are measured and of the fact that inventions now tend to be more technologically complex results in a rapid rise in R&D costs. It is entirely possible that reported R&D costs could increase while other measures of economic performance remain unchanged and yet have R&D still making a significant contribution through merely maintaining the existing rate of scientific innovation and economic growth.

Because of the difficulty in measuring the dollar expenditure of R&D over time, and especially prior to 1950, it is suggested that the measurement of input one should consider seriously is the change in R&D manpower. This has grown far lesa rapidly than R&D costs. From 1931 to 1960 the number of people engaged in R&D

went up 16 fold while R&D costs increased 47 fold.*

Moreover, when there are many variables affecting an activity, it is often extremely difficult or impossible to take a partial derivative to determine the impact that a change in one variable has on the whole. We have seen that this situation holds for economic analysis. If a government were to act unwisely by unduly tightening and/or by establishing restrictive tax structures, then it is probable that that economy would not grow rapidly. Incentive to invent, let alone to innovate, would be lost and productivity might fall. Should one say in such a situation that the inputs of R&D and of education are useless? When there are a set of variables which sometimes act in harmony and sometimes in conflict, it is often difficult to make specific correlations. Thus the recent burst in production that was observed in 1961 and 1962 came from wise government policies and the R&D effort plus education and increasing managerial expertise working in harmony. We do not think that economists have reached a stage in their art such that they can determine what part of the improvement is imputable to each factor. Therefore we cannot say that this recent increase in productivity is a result of more efficient R&D and education even though we are confident that these new inputs do affect the longer run change in productivity.

The Potential and the Problems of the 1960's

Our economy can be considered to be a great big wonderful toy with which we don't yet really know how to play. During the 60's the labor force will increase at a rate approximately 50% faster than that of the 50's. There is a lag sometimes

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* Research and Development: Its Growth and Composition, National Industrial Conference Board, Studies in Business Economics, No. 82, p. 21.

estimated at as much as ten years between inventive activity and its impact on the economy through innovation. We have every reason to believe that the expenditures of the 50's for education and R&D will pay off increasingly in the 60's.

As Gordon Brown indicated, the engineer or scientist graduating today is far better equipped than the one who graduated in the early postwar period. Professors of industrial management, we are sure, would agree with reference to their respective field. Thus, the pipeline of talented people has begun to fill in both a qualitative and a quantitative sense.

The utilization of computers is still in its infancy. The decade of the 60's will find the computer to be a most powerful managerial and scientific tool for the fostering of progress. It is clear that great increases in managerial efficiency will be accomplished during the 60's through more effective utilization of computers.

With respect to the rate of growth of GNP, the projections of the Department of Commerce are linked to our past trends in Chart I. It will be seen that expectations are very high. Yet the optimism of the Commerce Department is closely shared by many other economists. The NPA's most recent forecast to 1973 predicts a rate of growth of GNP of 4.5% a year, due in large measure to rapid productivity improvements.*

THE PROBLEMS OF THE 1960's

More Demand is Needed

We have no desire to echo Dr. Pangloss, for the best of all possible worlds is not yet here. We will be faced with two very critical problem areas in the 60's. First, the continuously advancing level of productivity that we have achieved

* New York Times, September 8, 1963.

requires a substantial and continuing increase in the level of demand of the economy is to be kept at full capacity utilization. This stimulation of demand is often urged as the solution to the unemployment problem which may become even more critical as the labor force increases during the 60's at a rate 50% faster than that of the 50's. American management need not be altruistic when it urges the government to promote policies for increasing demand and stimulating economic growth.

Managemement has discovered that costs have grown increasingly fixed as the economy has become more technologically complex in the postwar period. In manufacturing, depreciation as a percent of employee compensation has gone up from 5.8% to 13.1% between 1947 and 1962.* Production workers who can be easily laid off when business is slack have decreased from 83.6% of those employed in manufacturing in 1957 to 74.1% in 1962.**

The greater efficiency in capital utilization that we have observed has enabled management to increase capacity rapidly. If demand does not grow at a comparable pace, excess capacity and pressure on prices and profits will become worse.*** It is therefore no surprise that businessmen have actively campaigned for a tax cut. And it is our belief that the request for a dialogue on economic matters as urged by President Kennedy should be heeded. There is a much closer government-business-labor relationship in many European countries than in the United States.

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* U.S. Income and Output, pp. 216-217.

** Manpower Report of the President, March, 1963, pp. 163-164.

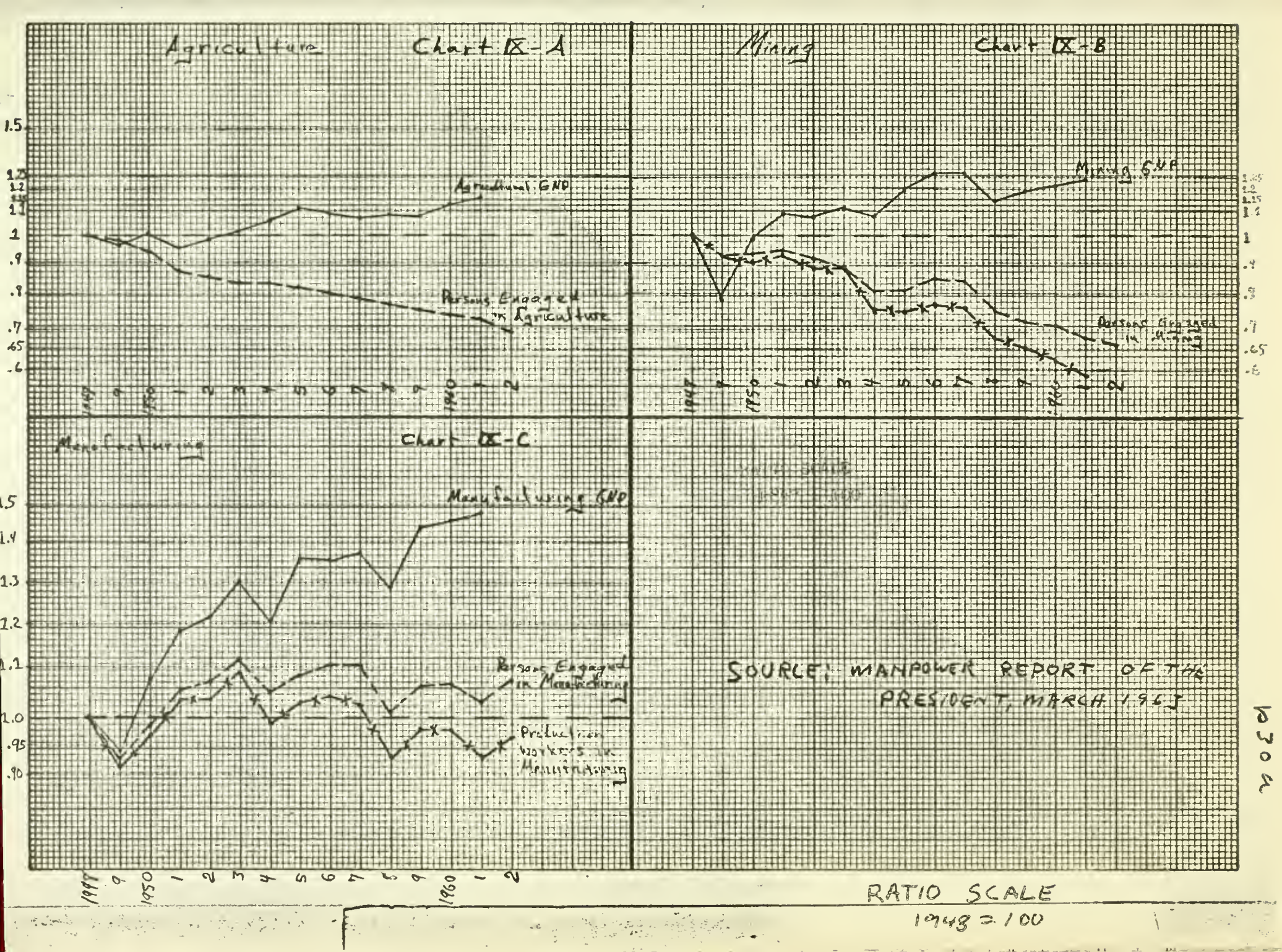
*** See Morrison and Neuschel, "The Second Squeeze on Profits," HBR, July - Aug. 1962.

It becomes increasingly clear that the United States can benefit from the experience of our European allies.

Structural Problems in the Labor Force

A second major problem area that must be encountered is the growing need for helping workers to adjust to the more technologically complex economy in which they work. If a laborer's special skills are no longer needed and if he does not have an adequate educational background enabling him to secure other employment, and further, if funds are not available for his retraining and/or for promoting his mobility as between economic regions, then such a worker can hardly be blamed for attempting to resist technological change.

And if such a worker loses his battle and joins the ranks of the unemployed, today's economy offers little help for him. It has often been said that automation creates more jobs than it eliminates. The unskilled worker, often with less than eight years of education, can only grin wryly and ask "for whom"? Chart IXA, IXB and IXC provide employment and output trends in manufacturing, mining, and agriculture between 1947 and 1962. While it is true that automation has increased total production and that total employment has grown during that same period, yet it is not true that the economy has provided a comparable number of jobs for the unskilled and/or displaced portion of the labor force. Business cooperation with labor and government for the promotion of retraining programs is clearly in order.


Agriculture
Chart IX-A
Agricultural GNP
Persons Engaged in Agriculture
Mining
Chart IX-B
Mining GNP
Persons Engaged in Mining
Manufacturing
Chart IX-C
Manufacturing GNP
Persons Engaged in Manufacturing
Production workers in Manufacturing
SOURCE: MANPOWER REPORT OF THE PRESIDENT, MARCH 1963
RATIO SCALE
1948 = 100

Conclusion

It is not yet certain which way the economy will turn. The tremendous progress that we have made since World War II despite a number of new burdens does not appear to have been fully appreciated. We have attributed much of the changed nature of the economy to three factors which have changed profoundly since 1929; the role of the government and increased expenditure for education and for R&D. The latter two can be linked into the generic area of knowledge. The role of the government depends increasingly on recent advances in economic theory.*

Thus, armed as never before with knowledge and a system for achieving progress, all that remains is for the country to utilize what is already available for its economic well-being. Whether our potential is realized will depend in large part on whether businessmen understand the issues and act in an enlightened way.

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* See R. L. Heilbroner and P. L. Bernstein, A Primer on Government Spending, Random House, New York, 1963, for a concise statement of this subject.

GNP in 1954 dollars, Commerce (2)	Percentage change in GNP from Preceding Year (3)	GNP at a 2.69% Rate of Growth 1909-1948 (4)	Deviation (2)-(4) (5)	Percentage Deviation (5) ÷ (4) (6)	BLS Index of Output per Man-Hour (1909 = 100) (7)	Kendrick Index of Output per Man-Hour (1909 = 100) (8)	
104.1		104.1	0	.0%	100.0	100.0	
106.8	+2.6%	106.9	-.1	-.1%	100.0	98.1	
109.5	+2.5%	109.8	-.3	-.3%	100.6	100.0	
116.1	+6.0%	112.8	+3.3	+2.9%	103.4	101.9	
116.9	+.8%	115.8	+1.1	+1.0	103.6	105.5	
112.1	-4.2%	118.9	-6.8	-5.7%	100.2	98.6	CHART
111.4	-.9%	122.1	-10.7	-8.8%	100.4	102.4	I, II, III
120.0	+7.7%	125.4	-5.4	-4.3%	101.3	110.0	IV B
120.5	+.4%	128.8	-8.3	-6.4%	98.1	104.5	
132.9	+10.3%	132.3	+.6	+.5%	102.3	112.9	
132.6	-.2%	135.9	-3.3	-2.4%	110.1	120.3	
125.6	-5.3%	139.6	-14.0	-10.0%	104.8	119.4	
114.9	-8.5%	143.4	-28.5	-19.9%	106.1	127.7	
133.9	+15.9%	147.3	-13.4	-9.1%	116.0	126.5	
149.2	+12.0%	151.3	-2.1	-1.4%	121.4	133.7	
149.0	-.1%	155.4	-6.4	-4.1%	123.7	139.7	
161.8	+8.6%	159.6	+2.2	+1.4%	130.0	139.5	
170.8	+5.6%	163.9	+6.9	+4.2%	133.0	143.3	
170.5	-.2%	168.3	+2.2	+1.3%	133.4	145.9	
171.8	+.8%	172.8	-1.0	-.6%	133.0	145.9	
181.8	+5.8%	177.4	+4.4	+2.5%	138.2	152.4	
164.5	-9.5%	182.2	-17.7	-9.7%	132.8	148.5	
153.0	-7.0%	187.1	-34.1	-18.2%	133.4	150.0	
130.1	-15.0%	192.1	-62.0	-32.3%	126.3	144.7	
126.6	-2.7%	197.3	-70.7	-35.8%	122.9	142.6	
138.5	+9.4%	202.6	-64.1	-31.6%	136.1	159.3	
152.9	+10.4%	208.0	-55.1	-26.5%	143.5	164.6	
173.3	+13.3%	213.6	-40.3	-18.9%	151.0	172.7	
183.5	+5.9%	219.3	-35.8	-16.3%	152.3	173.7	
175.1	-4.6%	225.2	-50.1	-22.3%	156.9	179.4	
189.3	+8.1%	231.3	-42.0	-18.2%	163.0	186.1	
205.8	+8.7%	237.5	-31.7	-13.4%	170.8	189.0	
238.1	+15.7%	243.9	-5.8	-2.4%	180.5	205.0	
266.9	+12.1%	250.5	+16.4	+6.6%	182.1	208.1	
296.7	+11.2%	257.2	+39.5	+15.4%	184.9	215.5	

APPENDIX D 2

(1)	(2)	(3)	(4) GNP at 3.5% Rate of Growth 1948-1962	(5)	(6)	(7) Goodland's Gen. Index of Output per man-hour (1900=100)	(8)
5	314.0	-1.2%	271.2	+42.8	+15.8%	206.9	242.3
6	282.5	-10.0%	278.5	+4.0	+1.4%	201.7	229.9
7	282.3	-.1%	286.0	-3.7	-1.3%	203.1	230.8
1948	293.1	+3.8%	293.1	0	.0%	210.3	238.7
9	292.7	-.1%	303.4	-10.7	-3.5%	216.4	247.8
50	318.1	+8.8%	314.0	+4.1	+1.3%	231.9	267.2
1	341.8	+7.4%	325.0	+16.8	+5.2%	237.6	273.4
2	353.5	+3.4%	336.4	+17.1	+5.1%	242.9	279.6
3	369.0	+4.4%	348.2	+20.8	+6.0%	252.7	290.9
4	363.1	-1.6%	360.4	+2.7	+.8%	257.1	297.8
5	392.7	+8.2%	373.0	+19.7	+5.3%	268.9	311.9
6	400.9	+2.1%	386.1	+14.8	+3.8%	269.1	314.5
7	408.6	+1.9%	399.6	+9.0	+2.3%	278.6	322.7
8	401.3	-1.8%	413.6	-12.3	-3.0%	285.5	
9	428.6	+6.8%	428.1	+.5	+.1%	296.0	
60	439.9	+2.7%	443.1	-3.2	-.7%	301.9	
1	447.7	+1.7%	458.6	-10.9	-2.4%	312.2	
2	474.8	+5.6%	474.8	0	.0%	325.0	

A more complete statistical appendix which provides data on the charts and tables not covered here is available upon request.

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